

450 RIGID PAVEMENT

ITEM 451 - REINFORCED PORTLAND CEMENT CONCRETE PAVEMENT

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451.01 Description. This work shall consist of a pavement composed of reinforced Portland cement concrete constructed on a prepared subgrade or base course in accordance with these specifications and in reasonably close conformity with the lines, grades, thickness, and typical cross sections shown on the plans or established by the Engineer.

451.02 Materials. Materials shall be:

Concrete.....	4499 Class C
Joint Sealer.....	705.04
Preformed elastomeric joint sealer.....	705.11
Preformed filler.....	705.03
Curing materials.....	705.05, 705.06, 705.07 (Type 2)
Reinforcing steel.....	709.09, 709.10, 709.12
Dowel bars.....	709.13
Expansion shield anchors.....	712.01

451.03 Equipment. Machines for finishing concrete pavement shall be mechanical, self-propelled spreading and finishing machines, and shall be capable of consolidating and finishing the concrete and which produces a finished surface meeting the requirements herein specified.

At the option of the Contractor, pavement shall be constructed with equipment utilizing stationary side forms or by the use of slip form paving equipment. Equipment shall conform to the following:

1. **Form Construction.** Concrete shall be uniformly spread, screeded and consolidated by one or more machines between previously set side forms. The number and capacity of machines furnished shall be adequate to perform the work required at a rate equal to that of the concrete delivery. These machines shall uniformly distribute and consolidate the concrete without segregation.

Vibration for the full width of paving shall be accomplished by internal vibrators operating at 7,000 - 11,000 impulses per minute. Vibrators may be attached to either the spreading or finishing equipment. They shall not come in contact with present load transfer devices, the subgrade, or the side forms. Power to vibrators shall be connected so that vibrators cease when the machines motion is stopped. The Contractor shall have available for the Engineer's use a tachometer, or other frequency measuring device, capable of verifying the frequency.

Machines shall be capable of operating either on side forms or on adjacent lanes of pavement. When concrete is being placed adjacent to an existing pavement, protective measures shall be taken to protect the adjacent pavement from damage. Any machine which causes displacement of the side forms from the line or grade or causes undue delay due to mechanical difficulties shall be removed from the work.

Small or irregular areas which are inaccessible to finishing equipment may be finished with other methods as approved by the Engineer. Vibration of these areas shall be accomplished by hand held or machine mounted internal vibrators. Vibrating shall be done to achieve adequate consolidation for the full depth and width of the area placed, without segregation.

Side forms shall be of steel, straight, and of a depth equal to the thickness of the pavement at the edge, except forms of greater depth than specified pavement thickness may be used by written permission of the Engineer. Any additional cost caused by the use of forms of a greater depth shall be included in the bid price for this item. The use of bent or damaged side forms or forms with damaged joint locks or pin pockets shall not be permitted. All forms shall be cleaned and oiled each time they are used. They shall be furnished in sections not less than 10 feet (3.0 m) in length, with horizontal joint and a base width equal to the depth of the forms. Flexible or curved forms shall be of a design acceptable to the Engineer and shall be used for construction of circular pavement edges where the radius is 100 feet (30 m) or less. Forms shall be provided with adequate devices for secure sitting so that when in place they will withstand the operation of the

paving equipment. Built-up forms shall not be used except where the total area of pavement of any specified thickness on the project is less than 2,000 square yards (1,672 m²). The forms shall contain adequate joint locks for joining the ends of abutting form sections together tightly.

2. **Slip Form Construction.** The concrete shall be placed with a slip form paver or combination of pavers designed to spread, consolidated, screed, and float-finish the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finish will be necessary to provide a dense and homogeneous pavement. The machine shall vibrate the concrete for the full width and depth of the strip of pavement being placed. Vibration shall be accomplished by internal vibrators attached to the pavers and operating at 7,000 - 11,000 impulses per minute. Vibrators shall not come in contact with load transfer devices or the subgrade. The Contractor shall have available for the Engineers' use of a tachometer, or frequency measuring device, capable of verifying the frequency.

The concrete shall be maintained at a uniform consistency, having a slump of not more than 3 inches (76 mm). The slip form paver shall be operated with as nearly a continuous forward movement as possible and all operations of mixing, delivering, and spreading concrete shall be coordinated as to provide uniform progress with stopping and starting of the paver held to a minimum. If for any reason, it is necessary to stop the forward movement of the paver, the vibrator and tamping elements shall also be stopped immediately. No tractive force shall be applied to the machine, except that which is controlled from the machine.

The finish grade of the pavement shall be accurately controlled from a grade line pre-set parallel to the finish grade. Slip form paving equipment shall have controls that will trace the grade line and automatically adjust the grade of the screeds or extension meters.

In areas where adjoining concrete pavement is to be constructed, the edge of the pavement on either side of the longitudinal joint shall not vary more than 1/4 inch (6.4 mm) below the typical section. The outside edges of the pavement shall not vary more than 1/2 inch (13 mm) below the typical section.

In the area of construction joints placed at the end of the days run, a reduction of approximately 2 inches (50 mm) in overall width will be permitted.

451.04 Setting Forms. All forms shall be set with reasonable conformance to the required grade and alignment and be supported on thoroughly compacted material for their entire length during the entire operation of placing and finishing of the concrete. After the setting of side forms the top face of the form shall not vary from a true plane more than 1/8 inch (3.2 mm) in 10 feet (3.0 mm) and the vertical face shall not vary more than 1/4 inch (6.4 mm) in 10 feet (3.0 mm), and they shall be tested by the Contractor and

variations from the above requirements shall be eliminated by resetting the forms. Shimming with loose earth, pebbles, etc., will not be permitted. The alignment and grade of all forms set shall be approved before and immediately prior to the placing of concrete.

451.05 Fine grading of Subgrade or Subbase.

1. **Form Construction.** After side forms have been set to line and grade and securely fastened, the subgrade or subbase shall be brought to final grade by means of a subgrader or subgrade planer. This fine grading operation should involve as light removal of the subbase material and bring the subbase to a smooth dense condition. The subgrade or subbase shall be checked using a multiple pin template operated on the forms or other methods approved by the Project Engineer. Any high or low spots found shall be corrected and rechecked.

In lieu of the above operation, forms may be placed on the subbase or subgrade which has been prepared as specified in Section 451..05

2. **Slip Form Construction.** After the subbase or subgrade has been placed and compacted to the required density, the areas on which the pavement is to be constructed and the areas which will support the paving machine shall be cut to the plan elevation by means of an automatic subgrading machine. If the density of the base is disturbed by the grading operations, it shall be corrected by additional compaction before concrete is placed. The grade shall be constructed sufficiently in advance of placing the concrete to permit checking. If any traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately ahead of placing of the concrete. If satisfactory stability of the subbase material cannot be obtained, it shall be stabilized by addition of admixtures or angular aggregate particles at no increase in cost.

451.06 Placing Concrete. To prevent damage from rain, the Contractor shall have available on the project approved material for protective covering, such as waterproof paper or polyethylene sheeting. The quantity of material required shall be of sufficient area to cover fresh concrete during a normal 1 hour operating period. No concrete shall be placed until this covering material is at the site of the work. The covering shall be placed on the concrete at the location and time so ordered by the Engineer.

The subgrade or subbase shall be sprinkled at such times and in such manner as directed by the Engineer so that it will be in a thoroughly moistened condition when the concrete is deposited thereon.

The concrete shall be deposited on the grade in a manner that requires as little rehandling as possible. Workmen shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign material.

Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them, but shall not be dumped from the discharge bucket or hopper onto a joint assembly unless hopper is well centered on the assembly. Concrete shall be consolidated around expansion and construction joints by means of internal vibration.

Sawing equipment necessary to saw joints is permitted to operate on the newly constructed pavement provided damage to curing membrane is repaired to the satisfaction of the Engineer. Other mechanical equipment shall not be operated upon existing lane of pavement until that lane has been in place for at least seven days or until specimen beams shall have attained a modulus of rupture of 600 pounds per square inch (4.2 MPa). If only finishing equipment is carried on the existing lane, paving may be permitted after that lane shall have been in place for at least three days or after specimen beams shall have attained a modulus of rupture of 500 pounds per square inch (3.5 Mpa).

An approved spreader will be required when the width of pavement being placed in one operation is 12 or more feet (3.6 m) and the total square yardage (square meters) of any given width on the project exceeds 10,000 square yards (8,300 m²).

No concrete shall be mixed, placed, or finished after dark, unless an adequate and approved artificial lighting system is operated.

For concrete placed when the temperature of the air is 35° F (2° C) or below, the concrete immediately after placing in the forms, shall have a temperature of between 50° F (10° C) and 80° F (27° C). *When the air temperature is greater than 35° F (2 °C) prior to placing, maintain a concrete temperature of not more than 90 °F (32° C).*

The subgrade or subbase upon which the concrete is to be placed shall be entirely free from frost when the concrete is deposited.

Concrete test specimens. Two test beams will be made from each 7,500 square yards (6,300 m²) or fraction thereof, that is incorporated in the work each day. Three test cylinders will be made from each 250 cubic yards (191 m³) or fraction thereof incorporated in the work.

451.061 Depositing and Curing Concrete During Cold Weather. *When an atmospheric temperature of 35° F or less exists at the time concrete is placed, or is predicted by weather forecasts to occur during the curing period, the following procedures shall apply:*

1. *The water or aggregate or both shall be heated as necessary to make the*

temperature of the concrete not less than 50° F (10° C) nor more than 80° F (27°C) when placed.

- 2. Once placed, the entire surface of the top and the sides of the newly placed concrete shall be covered and protected from freezing for seven days, unless beam specimens have attained the required minimum strength specified. Protection may be accomplished as directed in Item 511.12 with insulated blankets or a combination of loose straw 12 (0.3 m) inches thick covered with a securely fastened exterior cover of waterproof material.*
- 3. During the initial 24 hours of protection for base concrete only (Item 305 and 306), a layer of waterproof material may be used provided the atmospheric temperature is not expected to fall below 25° F (-4°C) and is expected to rise above 35° F (2° C) during that period. If the temperature falls below 25° F (-4° C) in the initial 24 hours, full protection as describe above must be utilized.*
- 4. The concrete shall be cured by maintaining the surface temperature between 50° F (10° C) and 100° F (37 ° C) for a period of not less than 5 days, except as modified below for concrete flooded with water. At the end of this curing period, the temperature shall be reduced at a rate not to exceed 20° F (-7°C) in 24 hours until it is within 20° F (-7° C) at atmospheric temperatures.*
- 5. If High-Early Strength concrete is desired and approved for the placement, the Contractor may use, at the Contractor's expense, additional cement in combination with calcium chloride in lieu of High-Early Strength Cement, Type III.*
- 6. Sufficient thermometers shall be furnished and installed by the Contractor in such a manner that the surface temperature of the concrete may be readily determined. The thermometers shall be read and recorded by the City inspector.*

451.07 Placing Reinforcement. When reinforced concrete pavement is placed in two layers, the entire width of the bottom layer shall be struck off to such length and depth that the mat of reinforcement may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed as specified directly upon the concrete, after when the top layer of concrete shall be placed, struck off, and screeded. When reinforced concrete is placed in one layer, the reinforcement may be positioned in advance of concrete placement or it may be placed in the plastic concrete, after spreading, by mechanical or vibratory means.

The mats of reinforcement forming each lap, in addition to being overlapped as specified, shall be securely fastened together at the edges of the sheets and at two additional points along the lap.

Reinforcing steel shall be free from dirt, oil, paint, and grease.

451.08 Joints. Joints shall be constructed of the type, dimensions, and at locations specified.

1. **Longitudinal Joint.** The longitudinal joint shall be constructed by sawing or by forming.

If the longitudinal joint between simultaneously placed lanes is made with a concrete saw, the sawing shall be done to a minimum depth of 1/3 of the specified pavement thickness within three days after the pavement is placed.

The width shall be approximately 1/8 inch (3 mm).

If the longitudinal joint between separately placed lanes is made with a concrete saw, the sawing shall be done to a depth of 1/2 inch (13 mm). The width shall be approximately 1/4 inch (6.4 mm).

If the longitudinal joint is formed, the groove for sealing shall be formed in the lane placed last.

Hook bolts, when used, shall be securely fastened to the form of the longitudinal construction joint.

Expansion bolt joints shall be constructed by installing expansion shield anchors in the center of the existing pavement slab in accordance with the manufacturer's recommendation after which hook bolts shall be threaded firmly into the expansion shield anchors.

2. **Load Transfer Devices.** Dowels shall be held in position parallel to the surface and centerline of the slab by an approved metal device that is left in the pavement. Dowels may be placed in the full thickness of pavement by a mechanical device approved by the Engineer. Deformed steel tie bars, when used for longitudinal joints, shall be placed by approved mechanical equipment or rigidly secured by chairs or other approved supports to prevent displacement.
3. **Expansion Joint.** Transverse expansion joints shall be provided on each approach to a bridge, or bridge approach slab at distances of approximately 20 feet (6 m) and 60 feet (18 m) or as specified. If the pavement is

constructed in two or more separately placed lanes, the joints shall form a continuous line for the full width of the pavement.

An opening 1 inch (25 mm) in width by 2 inches (50 mm) in depth shall be sawed for installation of Section 705.11 joint sealer or an opening 1 inch (25 mm) in width by 1 inch (25 mm) in depth shall be formed for installation of Section 705.04 joint sealer.

4. **Contraction Joint.** Contraction joints shall be sawed as specified to a minimum depth of 1/3 of the specified pavement thickness and a width of 1/4 inch \pm 1/16 inch (6.4mm \pm 1.6 mm) determined at the time of sawing. If the pavement is constructed in two or more separately poured lanes, the joints shall be continuous for the full width of the pavement. Sawing shall be done with sawing equipment approved by the Engineer. Joints shall be sawed as soon as the saw can be operated without damaging the concrete. Saws shall be equipped with adequate guides, blade guards, and a method of controlling the depth of cut. Sawing may be done wet or dry but the joint must be cleaned by a jet of water or air under pressure after having been sawed. A standby saw in working condition with an adequate supply of blades shall be maintained at the site of the work during the sawing of contraction joints.
5. **Construction Joints.** Construction joints shall be built as specified at the end of each day's work and whenever necessary to suspend the work for a period of more than 30 minutes. In no case shall an emergency construction joint be placed closer than 10 feet (3 m) to a parallel joint.

451.09 Finishing. The surface shall be continuously checked for trueness with ten-foot straightedges. If the pavement surface is dragged with a diagonal pipe float machine, only occasional straightedge surface checks, while the concrete is plastic, will be required.

Before the concrete has taken its initial set, the edges of the pavement along each side of each slab, and on each side of transverse expansion joints, shall be worked with an approved tool and rounded to the radius specified. Any tool marks left by the edging shall be eliminated by texturing the surface.

The surface shall be textured by use of a broom or artificial turf drag in the longitudinal direction so as to produce a uniform, gritty, longitudinal texture. In addition to and immediately following the above specified longitudinal drag texture, the pavement shall be textured in the transverse direction by an approved device that will produce a relatively uniform pattern of grooves. The grooves shall be spaced at approximately 5/8 inch (16 mm) centers and shall be approximately 0.15 inches (3.8 mm) deep and 0.10 (2.5 mm) inches wide. Variation from the texturing requirements will be permitted only with the written permission of the Director.

Station numbers shall be impressed into the pavement before it takes its final set. The complete station number is to be marked each 100 feet (30 m). Where equalities in alignment occur they shall be marked in the pavement in the same manner as they are shown on the plans. The numerals shall be 3 (76 mm) to 4 (102 mm) inches in height and 1/4 inch (6.4 mm) in depth. The station numbers shall be placed parallel with the pavement edge, and centered at 12 inches (305 mm) in from and facing the right edge of the pavement. On divided highways, station numbers shall be provided on both pavements. When concrete shoulders are placed with the traveled lane, station numbers shall be placed 12 inches (305 mm) in from the outside edge of the shoulder and facing the pavement.

451.10 Curing. Immediately after the finishing operations have been completed and after the free water has disappeared, all exposed surfaces of the concrete shall be sealed by spraying thereon a uniform application of curing membrane in such a manner as to provide a continuous uniform film without marring the surface of the concrete. The material shall be applied with a sprayer. Wind protection to the spray fog shall be provided by an adequate shield. A minimum of one gallon (3.7 L) of material shall be used for each 200 square feet (18.6 m²) of surface treated. Curing material shall be thoroughly agitated immediately prior to use.

On pavement with integral curb or small and irregular areas which are inaccessible to the mechanical spray machine, the curing material may be applied by a hand spray.

As soon as the forms have been removed, any honey-comb areas shall be immediately corrected and the edges of the pavement coated with the curing material. Any areas of pavement film that may have been damaged during the sawing shall be re-sprayed during this operation.

Curing may also be accomplished by means of water curing with burlap cloth, waterproof paper, or polyethylene sheeting.

Curing shall be applied as soon after the finishing operations as possible without marring the surface of the concrete.

The entire surface of the top and sides of the newly placed concrete shall be covered and maintained covered for seven days, and protected from freezing, unless specimen beams have attained a modulus of rupture of 600 pounds per square inch (4.2 MPa).

The above requirements for curing are minimum requirements only. Any concrete showing injury or damage due to inadequate curing shall be repaired or replaced by the Contractor at no additional cost.

451.11 Removing Forms. Forms shall be removed in such a manner that no damage will occur to the pavement. After the forms have been removed, the sides of the slab shall be cured as outlined in Section 451.10.

451.12 Surface Smoothness. After the final curing of the concrete, the surface shall be cleaned and tested for smoothness by means of a surface testing machine which will test one or more lines on each side of the pavement as determined by the Engineer. All surface variations so indicated shall be corrected to within the specified tolerance in a manner that will provide the required texture specified in Section 451.09. Pavement surface variations, except as herein after stated, shall not exceed 1/8 inch (3.2 mm) in a 10 foot (3.0 m) length of pavement.

For ramp pavements and for those pavements with curvature greater than 8 degrees, or with grades exceeding 67 percent, the surface variation shall not exceed 1/4 inch (6.4 mm) in 10 feet (3.0 m).

Sections of pavement containing depressions which cannot be corrected by grinding shall be repaired or replaced by the Contractor to the satisfaction of the Engineer.

451.13 Sealing Joints. Joints shall be sealed before the pavement is opened to traffic or to use by construction equipment, and as soon after completion of the sawing as is feasible. Just prior to sealing, each joint shall be thoroughly cleaned of all foreign material, using approved equipment, and the joint faces shall be clean and surface dry when the seal is applied.

Transverse contraction joints shall be sealed with preformed polychloroprene compression seals meeting the requirements of 705.11. Expansion joints shall be sealed with material conforming to 705.04 or 705.11. The seals shall be installed by suitable tools using an approved lubricant-adhesive which shall cover both sides of the sealer. The seals shall be installed in a substantially fully compressed condition and shall at all times be below the level of the pavement surface by approximately 1/4 inch (6.4 mm). The seals shall be in one piece without field or factory splice between longitudinal joint and edge of pavement or between longitudinal joints of multi-lane pavement. The elongation of the seals during installation shall not exceed 5 percent as determined by length measurement marks.

Formed joints shall be sealed with joint filler conforming to 705.04. Sawed joints shall be sealed with joint filler conforming to 705.04 or 705.11. The joint sealer shall be placed with proper equipment to obtain a neat workmanlike joint free from excess and unsightly filler.

451.14 Opening to Traffic. The completed pavement may be used for traffic, including construction traffic, when 7 days have elapsed. Provided that a modulus of rupture of 600 pounds per square inch (4.2 MPa) has been attained, the pavement may be opened to traffic when 5 days have elapsed. In the event it is necessary to open a portion

of the pavement in less than 5 days, high early strength concrete in accordance with Section 499.03 shall be used. The portion of pavement may be opened after 3 days provided test beams attain a modulus of rupture of 600 pounds per square inch (4.2 MPa).

451.16 Pavement Thickness. The City reserves the right to determine the thickness of the concrete street pavement by the measurement of cores cut at points on a random pattern established by the Engineer, with 1 core for every 2,000 square yards (1,672 m²) of pavement and a minimum of 3 cores. When cores are cut to determine the thickness of the concrete, the average thickness for the entire area of the project exclusive of any area with a deficiency of more than 1/2 inch (13 mm) shall not be more than 1/4 inch (6.4 mm) less than the specified thickness to secure full payment. All cores more than 1/2 inch (13 mm) greater than the specified thickness shall be considered as 1/2 inch (13 mm) more than the specified thickness. The average thickness of concrete on the entire project exclusive of any or all areas having a deficiency of more than 1/2 inch (13 mm) shall be considered to be the average depth of all cores taken with depths between the limits of 1/2 inch (13 mm) less than the specified thickness and 1/2 inch (13 mm) more than the specified thickness. All areas having an average deficiency of more than 1/4 inch (6.4 mm) and not exceeding 1/2 inch (13 mm) shall be paid for at the rate of the average actual thickness to the specified thickness applied to the pay quantity for the item.

Payment will not be allowed for any area having a thickness deficiency of more than 1/2 inch (13 mm) as hereinafter defined. Should any core show a deficiency greater than 1/2 inch (13 mm), additional cores shall be cut 5 feet (1.5 m), measured longitudinally, on each side of the deficient core, and additional cores shall be cut in a transverse direction on 1 or both sides of the deficient core in conformance to the previously determined pattern. If these additional cores are within the 1/2 inch (13 mm) tolerance, no further cores shall be cut for this particular area of deficiency. If either or both of the cores are not within the 1/2 inch (13 mm) tolerance, additional cores shall be cut at intervals of 50 feet (15.2 m), measured longitudinally, and also in a transverse direction as heretofore noted, from the core originally found to be deficient, until the thickness of the concrete is found to be within the 1/2 inch (13 mm) tolerance, but in no case shall such additional cores be cut beyond the location of any core in that lane at which the thickness is found to be within the 1/2 inch (13 mm) tolerance. The area of thickness deficiency for which no payment is to be made shall be computed as the product of the width of the separately poured lane in which the deficiency occurs, or one-half lane width if the transverse cores are found to be within the 1/2 inch (13 mm) tolerance, by the sum of the distances, measured parallel to the center line, from the location of the core originally found to be deficient to the nearest boring in each direction which produced a core within the 1/2 inch (13 mm) tolerance.

451.17 Method of Measurement. The area under this item will be the number of square yards (square meters) of concrete pavement completed and accepted in place. The width for measurements will be the width of the pavement shown on the typical cross section of the plans, additional widening where called for, or as otherwise directed in writing by the Engineer. The length will be measured horizontally along the center line of

each roadway or ramp. The plan quantities as adjusted for changes, errors, and deviation in excess of allowable tolerances will be the method of measurement.

451.18 Basis of Payment. The accepted quantities of concrete pavement will be paid for at the contract unit price per square yard (square meter), which price and payment shall be full compensation for furnishing and placing all materials including reinforcing steel, dowels, and joint materials; provided, however, that for pavement found deficient in thickness only the reduced price stipulated in Section 451.16 shall be paid.

No additional payment over the unit contract bid price will be made for any pavement which has an average thickness in excess of that shown on the plans.

Payment for accepted quantities, complete in place, will be paid for at the contract price for:

Item	Unit	Description
451	Square Yard (Square Meter)	Reinforced Concrete Pavement